Bilboa, Spain, at the now-defunct Atace Shipyard. Today, 20 years later and with close to 400,000 miles under her keel, she's proven herself time and time again to be a safe and comfortable oceangoing vessel. More importantly, an entire industry of SSVs now ply coastal and offshore waters, and all are platforms for teaching our nation's youth about life at sea.

For SEA, Rod Stephens's suggestions were largely written to help us avoid the many pitfalls that he'd experienced during a lifetime of sailing. Most all were incorporated, and much of the safety by which we operate can be traced to the knowledge and standards of this visionary sailor.

John W. Bontrager
Port Engineer
Sea Education Association
Woods Hole, Massachusetts

Smarter, Faster Tabbing

To the Editor:

I was a little surprised to see the article "Smarter, Faster Tabbing" in PBB No. 119. Most wet-out equipment requires cleaning; in addition, the equipment Bruce Pfund describes has a serious exotherm-related heatbuildup issue. Combined, those problems make the equipment described of very limited usefulness.

The extremely inexpensive WOMBAT Junior tape-impregnating machine by Adhesive Technologies (ALT Composites, Queensland, Australia) is one of only two wet-out machines that require no cleaning. Used as suggested, it also has no residual resin exotherm issues, by virtue of its unique design.

Arnold Duckworth
Phuket, Thailand

Bruce Pfund responds:

I am familiar with the WOMBAT and WOMBAT Junior, and agree completely that their elegant features address the many shortcomings of the crude wet-out device I wrote about, including but not limited to cleanup and residual exotherm. On cleanup, I did suggest the options of facing the rolls with appropriate tapes and making a disposable bag inside the wet-out tank, which would mostly eliminate the need for solvents during cleanup.

Since the device I illustrated is less expensive than the WOMBAT, and quickly made from scrap materials commonly found in most boatshops, laminators can experiment with the wet-out-box concept at low expense. Given its limitations, my wet-out box worked just fine for the small application illustrated in the article, where resin dwell time in the tank was short. Residual exotherm issues with vinyl ester resin were never a problem, despite the hot working conditions.

Nuts. Bolts. Screws.

To the Editor:

The cover of the April/May issue of *Professional BoatBuilder* (No. 118) is the subject of a discussion topic sometimes raised in order to feel out the experience level of boatbuilders. The question is: "In the proper installation of a propeller, does the big nut go on first, or does the small nut?" In my experience, answers usually are split 60/40 in favor of the big nut first. The second, smaller nut locks the first in place, right? While visiting a boatyard recently, where those who "know" are installing the props, I looked at the boats in dry-dock to see how the installation was done. I found about a 50/50 split, big first/small first. Of course, the photo on the cover is correct: small nut first. As I understand it, the second nut will compress the first, releasing the contact between the threads of the first nut and the shaft somewhat. The threads of the second, bigger nut will fully engage the shaft threads. The smaller nut will essentially become a washer, capable of holding the prop in place if necessary.

It would be interesting, perhaps scary, to publish how many, if any, professional boatbuilders were compelled to write to inform you the cover picture was incorrect.

James Sireci
Engineer
Zodiac of North America
Stevensville, Maryland

To the Editor:

Let me start by complimenting you on a thorough and professional article on fasteners in the April/May issue of *Professional BoatBuilder*. But seeing the picture on the magazine's cover, of the small prop-nut on first, drives me up the wall, and nuts. (Please forgive the pun.) I have been an engineering executive for more years than I want to admit, and have had some of the best in the business working for me, not boat building and repair but other professions, and none of them can accept this concept. I fought this out on Mainship's Web site several years ago. When the chips were down it was apparent that no one really understood the "small nut on first" concept.

So, being an old guy that is still willing to learn, I offer the following and request your explanation of where I am going wrong.

There are two failure modes for the situation at hand: the nuts come off, or the thread breaks at the root diameter. I guess the possibility also exists for the threads to strip, but I don't see a scenario that could cause that. Even violently running aground only wraps the blades around the rudder and hub. Bending the blades absorbs most of the energy that might result in stripping the threads.

The only time the thread or nuts see any load is in the initial installation, backing up, or slowing down. And the only time the thread would probably see those loads (backing up or slowing down) is if the nuts have loosened and the prop has vibrated loose of the taper. We may also have to include running aground. After a boat has been in the water for some time, you probably could run it with no nuts and it would be a little while before the prop came off. (I'm sure of that, having seen, more than once, a mechanic in a boatyard banging on the prop with a sledgehammer—after he's tried every other technique to remove it.) I admit I've lost one prop in my illustrious boating career, but of course have no idea how long the nut was off.

The two criteria we try to achieve in attaching a prop are to ensure that it is well seated on the taper, and that any failure takes place at the root of the threaded shaft. Hence, the old rule of one-and-half times the thread diameter for the length of the nut. This assures the failure taking place at the root, and the long nut. Since Archimedes, the small nut is used as a jam nut to prevent the big nut from loosening.

I do not know the recommended

torque specs for putting on the first nut, but I think they would be substantial to assure that the taper is properly seated. I also imagine the prop shaft is harder than the nuts. If the small nut is put on first and any reasonable level of torque is attempted, then to ensure proper seating of the taper, there is a good possibility the inside of the little nut would strip.

Russ Lester
Ultimate Die Corporation
Tampa, Florida

To the Editor:

The cover of the April/May issue shows an incorrect propeller nut and shaft assembly. That procedure came about at the same time as the crush-type lock nut, which we all threw away as being impractical. Since then, the self-locking feature was moved to the head of the nut, so it wouldn't be crushed when the nut was tightened. New methods of fastening were recommended, including putting the bolts on upside down with the nut on top, and/or putting the bolt head in the back with the nut in the front. None of these procedures should be used today, as they are backward and impractical.

We recommend that a flat washer be used next to the propeller, with two drops of light (30-weight) oil on the face that will contact the thrust face of the securing nut—not a jam (half) nut. Only a full nut with the flat surface (thrust face) should be snugged up—*not over-tightened*—against the flat washer, until it fully seats the propeller on the dry, tapered shaft. We usually put two drops of oil on the shaft threads to make the full nut easier to remove the next year, so nicks in the propeller can be straightened. After installing the full nut firmly on the shaft, install the jam nut, which has no thrust face. The jam nut should not be used against a thrust load because it doesn't have sufficient threads to withstand a thrust load. If the jam nut *is* placed against a thrust load as shown in your cover photo, the propeller will push back against the jam nut until it deforms or galls the threads of the nut and shaft. Also, the shaft key would be damaged, along with the slot—resulting in a loose, vibrating/wobbling propeller. After snugging up the jam nut, install the proper cotter pin, which must be bent around the back of the nut—not left sticking out beyond the nut as shown.

Many other practices by small boatyards are discovered only after the damage is done. Do not put grease on the tapered shaft or on the threads; it can result in overtightening the nuts, in which case you need a blowtorch to heat the nut so the puller can remove the propeller. Also, you shouldn't need a sledgehammer on the end of the shaft with the wheel puller—though sometimes it, too, is necessary, because someone has overtightened the nut. It's important to clean the tapered section of the shaft, so no high spots are on the taper before installing the propeller. The propeller should fit on the taper all the way, requiring only a small amount of tightening to fully secure the prop. A new key may be installed on an older replacement, as wear on the key's edges may have been caused by a loose propeller installed improperly with a jam nut.

Also, we do not recommend bronze nuts on stainless shafts (as shown in the cover photo), as they may cause some galvanic flow of electrons or migration of metal. Instead, we recommend bronze nuts only on bronze shafts, and SS nuts on SS shafts.

We have installed hundreds of propellers on our personal boats as well as on commercial and naval ships for over 16 years. The reverse procedure shown on the cover of your magazine is not used in any boatyard or shipyard that I'm aware of.

The propeller on the cover is a very old type but is efficient, and we intend to employ this same design of propeller on our FAST Tanker—the first newly designed commercial ship in over 50 years. It has a non-trip chine for greater maneuverability up our ship channels.

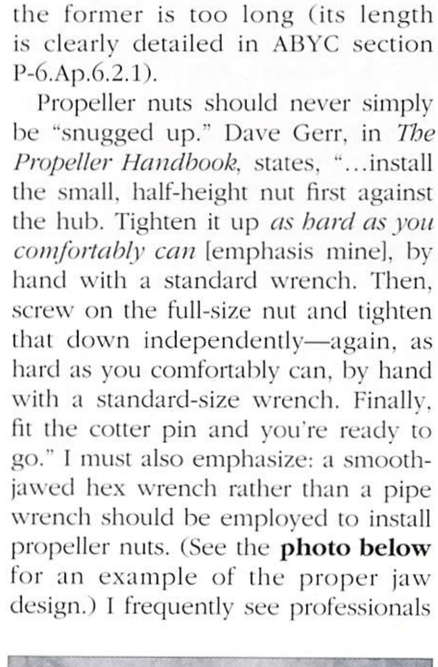
Wesly C. Lilly
President, Saturn Marine Engineering
Amelia Island, Florida

Steve D'Antonio responds:

I thank Mr. Lily for his comments regarding the propeller nut installation shown on the cover of the April/May issue. I'm afraid I must disagree not only with his assertion that the nuts are incorrectly installed, but must also refute most of his other suggestions.

The propeller nut installation protocol shown on the cover is accepted by the American Boat & Yacht Council via their endorsement of standards set forth by the Society of Automotive Engineers along with: the U.S. Coast Guard; Michigan Propellers; and author, designer, and director of the Westlawn Institute of Marine Technology Dave Gerr. All of them subscribe to this approach. (See details in three specific **documents, on pages 14 and 15.**) The half-height nut, which you call a "jam nut," carries the load until the full-height nut is installed and torqued, at which point the bulk of the load is transferred to its more substantial thread face area. Neither the key nor the "slot" (the keyway) will be damaged unless the former is too long (its length is clearly detailed in ABYC section P-6.Ap.6.2.1).

Propeller nuts should never simply be "snugged up." Dave Gerr, in *The Propeller Handbook*, states, "...install the small, half-height nut first against the hub. Tighten it up *as hard as you comfortably can* [emphasis mine], by hand with a standard wrench. Then, screw on the full-size nut and tighten that down independently—again, as hard as you comfortably can, by hand with a standard-size wrench. Finally, fit the cotter pin and you're ready to go." I must also emphasize: a smooth-jawed hex wrench rather than a pipe wrench should be employed to install propeller nuts. (See the **photo below** for an example of the proper jaw design.) I frequently see professionals



STEVE D'ANTONIO

A smooth-jawed hex wrench is the proper tool for installing propeller nuts.

handling pipe wrenches to install propeller nuts, or the aftermath: mangled nuts.

Flat washers and motor oil are not prescribed for propeller nut installations by any of the aforementioned organizations. Applying oil on the shaft threads to "make the nut easier to remove next year" is simply unnecessary. The last thing the installer of a propeller should be thinking about is how to encourage ease of removal. The prop and nuts are to be installed in such a way that removal is possible with the correct tools. A full-size hex wrench will easily remove properly installed nuts without the use of oil. It's likely the oil will be washed out, anyway, once the vessel is put into service. Proper molybdenum-based thread lubricant may be applied to avoid thread galling when stainless steel nuts are installed on stainless alloy shafts; there's a preferable solution to that, too. Read on.

Even if it were an issue, the propeller would only "push back against the jam nut" when it was in reverse. For the majority of the propeller's life it's pushing itself *onto* the shaft taper via forward thrust.

In the cover photo, the cotter pin does not protrude past the edge of the nut. Even if it did, that would in no way compromise its integrity.

We do agree: grease should never be applied to a shaft taper or threads, but not because it will lead to overtightening. Applying grease, an incompressible medium, to a shaft taper will result in hydrolock, preventing the prop bore from engaging the shaft taper, and thus resulting in a loose propeller.

We agree once again: the propeller should fit fully onto the taper; but our procedures differ markedly. Propeller shaft tapers require more than cleaning, particularly for first-time installations; they must be blued and lapped to remove irregularities in the typically softer propeller alloy, rather than the shaft. The lapping process ensures the fullest possible taper engagement. After the lapping is believed to be complete, the propeller should be installed onto the shaft (a very light film of oil can be applied to the taper to prevent binding; I typically recommend no more oil than can be applied to one's finger) *without* the key. A line is then scribed on the shaft at the forward end of the propeller hub. Next, the propeller is removed, the key installed, the propeller re-installed, and nuts torqued, in the correct order. The propeller hub should reach or overcome the scribed line; if it doesn't, the key is causing it to bind and an adjustment must be made. Following this procedure ensures a bind-free propeller and key fit. Finally, installing bronze nuts (most are in fact manganese bronze, a form of brass that is also the same material as many propellers) is not only acceptable, it's preferred. Installing stainless steel nuts on a stainless alloy shaft often leads to galling, the prevention of which requires the aforementioned lubricant. Copper alloys such as brass and bronze have self-lubricating properties that virtually eliminate galling. Given the choice, and for this reason, I always specify a copper alloy nut on a stainless alloy shaft. A "galvanic flow of electrons" between the shaft and nuts is no more likely than a similar flow of electrons between the shaft and a propeller. In any case, this is precisely why shaft anodes are applied.

Thanks also to Mr. Lester for his interesting, though not unique, query. This entire subject—securing the prop—invariably prompts strong opinions. Each time I mention the order of shaft nuts in an article, it generates mail. I welcome the discourse, and the opportunity

Michigan Wheel Corporation

Michigan propellers

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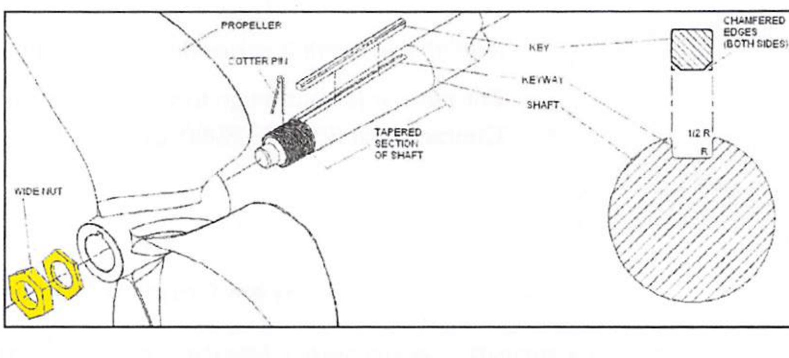
INBOARD PROPELLER INSTALLATION PROCEDURES

1. Push propeller snugly onto shaft taper WITHOUT key in either keyway (propeller or shaft).
2. Make sure the propeller is snug and there is no side to side movement by gently moving propeller back and forth.
3. Make a line on the shaft with a non-graphite marker at the forward end of the propeller where it stops up against the shaft taper.
4. Remove Propeller.
5. Put key into keyway on shaft taper with radiused or chamfered corners (down) in shaft keyway (if propeller shaft keyway has radiused corners).
6. Put propeller onto shaft taper.
7. Check to see that the propeller moves back to the forward line made in Step 3. If it does, skip down to Step 8. If not, perform the following:
   a. Remove propeller from shaft.
   b. Place a file on a flat surface area or work bench.
   c. Run opposite end of chamfered key back and forth over file (to remove any burrs) with a downward pressure on key until side being filed is clean.
   d. Install cleaned key in shaft keyway with chamfered corner side down in shaft (the cleaned, filed side up in keyway).
   e. Replace the propeller on the shaft and fit snugly on taper. Check to see if it reaches the line made as in Step 7. If it does not line up then repeat "Steps a. through e.".

   NOTE: A vise can be used to hold key and then filed, but care must be taken not to tighten too much, causing burrs and irregularities on key.
8. When propeller hub moves to correct position, install propeller nut on shaft and torque to seat the propeller. Install the torque jam nut also, if your shaft is so equipped.
9. Install cotter pin at end of the shaft.



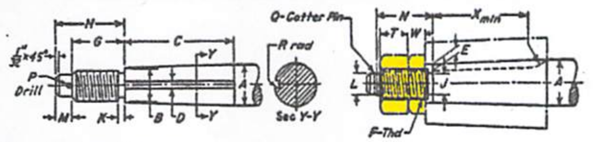
MICHIGAN PROPELLERS

7/02

APPENDIX TO P–6 *(PROPELLER SHAFTING)*

Those portions of SAE J 755 and SAE J 756 that normally apply to recreational boat design and construction have been reproduced herein as a convenience. The complete standards may be obtained from SAE. The Society of Automotive Engineers, Inc. has granted permission for the inclusion of this material.

MARINE PROPELLER–SHAFT ENDS AND HUBS - SAE J755 SAE Standard



TAPER = 3/4 IN. ON DIAMETER PER FT = 1/16 IN. PER IN. = 3 DEG 34 MIN 47 SEC TOTAL INCLUDED ANGLE

FIG. 1–PROPELLER-SHAFT ENDS

Tolerances for SAE Marine Tapers–Surface Finish–The machined surfaces of propeller hubs and shafting shall be equal to that defined by American Standard B46 as Roughness Symbol 60, which denotes that the root mean square average height of surface irregularities shall not exceed 60 Mu in. (microinches).

Basic Dimensions–Taper per foot measured on the diameter and diameter of small end of taper shall be basic dimensions.

Taper Tolerances for Hub Bores

Sizes 3/4 to 1 1/4 in. inclusive, 0.7500 (+0.0000, –0.0020) in. taper per ft.
Sizes 1 3/8 to 2 in. inclusive, 0.7500 (+0.0000, –0.0019) in. taper per ft.
Sizes 2 1/4 to 3 in. inclusive, 0.7500 (+0.0000, –0.0015) in. taper per ft.

Taper Tolerances for Shafts

Sizes 3/4 to 1 1/4 in. inclusive, 0.7500 (+0.0020, –0.0000) in. taper per ft.
Sizes 1 3/8 to 2 in. inclusive, 0.7500 (+0.0019, –0.0000) in. taper per ft.
Sizes 2 1/4 to 3 in. inclusive, 0.7500 (+0.0015, –0.0000) in. taper per ft.
Sizes 3 1/4 to 5 1/2 in. inclusive, 0.7500 (+0.0015, –0.0000) in. taper per ft.
Sizes 6 to 8 in. inclusive, 1.0000 (+0.0015, –0.0000) in. taper per ft.

Basic Data–Keyways–The keyway shall be cut parallel to taper At the small end of the hub length and shaft taper length, the keyway shall have the specified side depth. The keyway side depth shall be measured normal to the axis of the taper, not normal to the surface of the taper.

Keys–Keys for use in filleted keyways must be chamfered so that the corners of the key do not touch the keyway fillets.

Small-End Diameter of Taper for Hubs–For nominal bore diam-

MAY 88 MLCPAC ASSIST FULCRUM 1ST YEAR No 3

From the SPEC BRANCH(MLCPvs):

ARE YOUR NUTS ON BACKWARD!

Traveling around the Coast Guard units, it appears that not all Coasties know the proper sequence for installation of propeller nuts on small boat propeller shafts. In too many cases, the narrow nut is observed installed on last after the thick nut. This is wrong! When two propeller nuts are used and one is thicker than the other, the thicker one goes on after the thin one. Refer to the figure below if these words are a little confusing.

The first figure is right from the 41'UTB BOSS Manual. The second figure is from SAE Standard J755. This is somewhat surprising since SAE stands for the Society of Automotive Engineers. However, this large standards body has a Marine Propeller and Coupling Committee within its Motorboat and Marine Engine Division to develop boat related mechanical standards. OK, now you're convinced this is the right way but why?

Many people think the thinner nut goes on last because it is a jam or locking nut and should be on the outside to lock the larger nut. It is indeed a locking nut, but performs its function best when installed correctly. Here's what could happen if the nuts are reversed. The large nut gets torqued up against the propeller which is on the shaft taper. When you put on the small nut and torque it up, you are actually unloading the large nut and forcing the thin nut with fewer threads to carry much of the load. In extreme cases, the thin nut can deform slightly and loosen. Once it loosens, the nuts can back off. While this may not cause a loss of propulsion because the cotter pin should prevent the nuts from going all the way, it could cause vibration when the propeller slips off the taper and starts to "work" on the key and keyway.

With that in mind here's what should happen. The propeller should be driven up on the shaft taper with the large nut and torqued. The large nut is then taken off and the thin nut is installed and torqued. The final step is to install the large nut again which, when torqued, unloads the thin nut and bears most of the load. Notice that in this proper configuration, the thin nut still performs the locking function but acts more like a washer in transferring the force from the large nut to the propeller.

So, take a look at your small boats and make sure your nuts are not on backward!! (and please don't write in asking what to do if the nuts are the same size, the answer could not be printed here!)

USCG

P-6
7/02

P-6 *APPENDIX 1 - MATERIALS, SIZE AND INSTALLATION OF PROPELLER SHAFTING SYSTEMS*

P-6.Ap.6.1 If the propeller shaft does not have sufficient flexibility to prevent overstressing the bearings at the marine transmission, a flexible coupling or a floating section of shafting shall be installed with engines equipped with flexible mounting systems.

P-6.Ap.6.2 If a double nut and key system is used, it should consist of the following components;

a. a straight key,
b. jam nut (thin - identified as "W" in Figure 1 of SAE J755, *Marine Propeller - Shaft Ends and Hubs*),
c. plain nut (thick - identified as "T" in Figure 1 of SAE J755, *Marine Propeller - Shaft ends and Hubs*), and
d. cotter pin.

P-6.Ap.6.2.1 The length of the key should not exceed the dimension "x" minus one-quarter inch (6.35 mm) in SAE standard J755, *Marine Propeller - Shaft Ends and Hubs.*

ABYC (BOTH)

***Above left** and **left**—A portion of a Society of Automotive Engineers document reproduced for the American Boat & Yacht Council, indicating the recommended propeller nut installation: i.e., small nut first. **Above**—The U.S. Coast Guard, too, instructs its personnel to install the small nut first.*

to share with folks the "approved" method.

Since I didn't invent the "small nut first" dictum, I'm only a partisan to this cause. I take neither credit nor blame for its propagation. Instead, that would have to be directed, as mentioned before, toward: the Society of Automotive Engineers, ABYC, the U.S. Coast Guard, Michigan Propellers, and Dave Gerr, to name a few.

New & Improved

To the Editor:

As a follow-up to Ed Sherman's "New & Improved" article in PBB No. 118, the American Boat & Yacht Council would like to inform readers that the Council published a Technical Amendment to the July 2008 version of ABYC's Electrical Standard, E-11, *AC & DC Electrical Systems on Boats.* The amendment applies only to section E-11.11.1 and its subsections, and specifically addresses a new device called the Equipment Leakage Circuit Interrupter, or ELCI. This amendment appears in the 2009–2010 edition of ABYC's *Standards and Technical Information Reports for Small Craft,* which is provided annually to ABYC members by July 31.

The amendment appears as a "Note" in the recent edition of the ABYC Standards, both in the leading paragraph and prior to the section E-11.11.1, and reads as follows:

NOTE July 2009 Technical Amendment: Based on ABYC's assessment of the existing technology regarding the Equipment Leakage Circuit Interrupter (ELCI), E-11.11.1 and its subparts carry a recommended compliance date of July 31, 2010.

As stated, the recommended compliance date for section E-11.11.1 has been extended by one year to July 31, 2010, whereas the recommended compliance date for *all other* portions of the July 2008 version of E-11 remains July 31, 2009. E-11 is on a three-year review cycle and will be re-published in July 2011.

The ELCI device is a new concept based on existing technologies. Although several manufacturers are already committed to producing ELCI units that meet the needs of builders and the requirements of E-11's 2008 version, ABYC's Technical Board of Directors and the Electrical Project Technical Committee agree that an additional year is needed to incorporate the 30-, 50-, and 100-ampere ELCI units into boats. Not only do the devices have to be sourced by boat manufacturers, they must also be engineered into boat designs.

John Adey
Technical Director, ABYC
Annapolis, Maryland

PBB